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Effects of herbicide-induced habitat alterations on blackbird damage to sunflower

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In August 1992, we treated cattail-dominated wetlands in four 23-km^2 blocks with aerially-applied glyphosate herbicide (5.3 l ha^{-1}). Four other blocks of wetlands were left untreated (reference). We assessed the effects of cattail (*Typha* spp.) reduction on roosting blackbird (Icterinae) numbers and sunflower damage within the blocks. Blackbird numbers did not differ between posttreatment years ($P = 0.453$) or between treated and reference wetlands ($P = 0.469$), averaging 6227 ± 4185 (SE) birds per block. Sunflower damage within blocks was similar between posttreatment years ($P = 0.250$) and did not vary ($P = 0.460$) between treatments ($\bar{x} = 2.9 \pm 1.2\%$). However, positive linear relationships were detected between blackbird numbers (y) and hectares of live cattails (x) [$(y = 442.2\ x)$] ($P = 0.006$) and between blackbird numbers (x) and kilograms of sunflower lost per hectare per year (y) [$(y = 0.003\ x)$] ($P = 0.0001$). Cattail reduction appears to discourage roosting blackbirds and, thus, may reduce sunflower damage in adjacent fields.

Keywords: blackbirds; cattails; damage; emergent vegetation; habitat; Icterinae; sunflower; *Typha* spp.; wetland management

In the northern Great Plains, millions of blackbirds (Icterinae) roost in cattail-dominated (*Typha* spp.) wetlands during fall migration (Stehn, 1989). These birds usually roost near sunflower fields (Otis and Kilburn, 1988) and during August and September can eat substantial amounts of sunflower seed (Hothem, DeHaven and Fairazl, 1988). In 1992, 87 of 548 North Dakota sunflower growers reported bird damage exceeding 10% (Lamey *et al.*, 1993).

Bird frightening agents (Knittle *et al.*, 1988), mechanical devices (Bomford and O'Brien, 1990) and modified agricultural practices (Cummings *et al.*, 1987) developed for reducing blackbird damage to ripening sunflower fields have limitations of cost, logistics or efficacy (Baltezore, Leitch and Linz, 1994; Linz *et al.*, 1993). Thus, new management techniques for dispersing blackbirds and reducing damage to sunflower are needed.

Linz, Bergman and Bleier (1992) reported that fragmenting dense cattail-dominated wetlands with glyphosate herbicide [*N*-(phosphonomethyl) glycine] reduces roosting populations of blackbirds. Dispersing congregations of blackbirds by altering their roosting habitat may in turn reduce damage to surrounding sunflower fields. Additionally, the increased ratio of open water and cattails may increase the abundance and diversity of wetland-dwelling birds (Kantrud, 1986).

The objectives of this study were to (i) determine the efficacy of glyphosate for reducing cattails in shallow-basin wetlands and (ii) describe the relationships between the number of roosting blackbirds in wetlands, coverages of cattails within wetlands, and sunflower damage in fields surrounding wetlands.

Materials and methods

Study area and methods

The study area was located in Dickey, Forman, LaMoure and Ransom counties in the southern Drift Plains of North Dakota. The drift plains are characterized by the presence of many shallow-basin wetlands, which are subject to large annual variations in water coverage (Stewart and Kantrud, 1974). The land is 65% cropland (largely small grains, sunflower and corn), 20% grassland and 13% wetlands (C. McMurl, North Dakota State University, Fargo, North Dakota, unpubl. data). The area receives 77% of its annual precipitation between April and September (North Dakota Agricultural Statistics Service, 1994). Long-term average precipitation and temperature in southeastern North Dakota are 48 cm and 5.5°C, respectively (North Dakota Agricultural Statistics Service, 1994).

In 1992, we initially searched a 10 551 km^2 area for semi-permanent wetlands (Class IV; Stewart and Kantrud, 1971) using false-color-infrared photographs taken by the National Aerial Photography Program. Potential study wetlands >10 ha were aerially inspected to check for cattail coverage >70%. On-site inspections were conducted to exclude wetlands with <30 cm of water in the deepest portion of the wetland.

Eight wetlands, located at least 8 km apart, were selected from a pool of 33 semipermanent wetlands.

Each wetland was centered within a 23.3 km^2 block of land and was designated as the principal wetland. We determined wetland size and coverages of open water, live cattails and other vegetation (i.e. vegetation not normally used by roosting blackbirds such as live sedges, Cyperaceae; grasses, Poaceae; rushes, Juncaceae; and dead vegetation) from aerial color-infrared photographs using geographic information system software (Map and Image Processing System, MicroImages, Inc., Lincoln, Nebraska).

We randomly designated the blocks as either treated or reference. In mid-August 1992, at least 70% of each wetland within the treated blocks was treated at an application rate of 5.3 l ha^{-1} of glyphosate (Rodeo® formulation, Monsanto Company, St. Louis, MO, USA) in a 46.7 l ha^{-1} solution containing 0.2 l ha^{-1} surfactant (Valent X-77 Spreader, Valent U.S.A. Corporation, Walnut Creek, CA, USA) and 0.6 l ha^{-1} drift retardant (Chem-trol, Loveland Industries, Inc., Greeley, CO, USA). The herbicide was applied with a fixed-winged agricultural spray plane in strips 15-m wide and ran along the long axis of the wetland. The pilot skipped approximately 6.4-m strips of vegetation between each treated strip.

During mid-August 1992–1994, blackbirds were counted as they exited the principal wetlands at sunrise (Meanley, 1965). Blackbirds did not roost in the secondary wetlands within the blocks.

In late September 1992, 25% of the sunflower fields within each block were randomly selected for damage assessments. In 1993 and 1994, we increased our assessments to 50% of the sunflower fields in the blocks. Each field was divided into four equal-sized strata. One row was randomly selected from each stratum, and 24-1.5 m plots were proportionally distributed among the four rows based on their length. Plot interval was determined by dividing the total length of the row by the number of plots assigned to that row. The location of the first plot in each row was a randomly selected distance between the field edge and the first plot interval. The diameter of each head and undeveloped center was measured to the nearest centimeter with a measuring tape. The area of seed (cm^2) missing from the head was estimated with a gridded plastic template (Dolbeer, 1975).

Statistical analyses

Analyses of variance (ANOVA) and repeated measures (RMANOVA) (Cody and Smith, 1991) were used to test the null hypotheses of no treatment effects during pretreatment (1992) and post-treatment periods (1993 and 1994), respectively, for the following variables: (i) percent coverages of water, live cattails and other vegetation, (ii) numbers of blackbirds roosting in wetlands, (iii) percentage of sunflower damage and (iv) sunflower production loss per hectare.

Linear regression analyses, using the no intercept option (NOINT) in the Statistical Analysis System (Cody and Smith, 1991), were used to describe the relationships (regardless of treatment and years) between blackbird numbers and (i) per cent coverage of live cattails, (ii) hectares of live cattails, (iii) per cent sunflower damage and (iv) sunflower production loss per hectare. The alpha level was set at 0.1 (*a priori*) for all statistical tests because resources were not sufficient to increase sample sizes (Tacha, Warde and Burnham, 1982). Means and standard errors are reported as $\bar{x} \pm SE$.

Results

Habitat characteristics

Pretreatment. The sizes (ha) of the principal wetlands did not differ (ANOVA, $P = 0.817$) between treated and reference blocks, averaging 38.01 ± 7.01 ha. Per cent water coverage did not differ ($P = 0.714$) between assigned treatments ($\bar{x} = 5.4 \pm 1.9\%$, *Figure 1*). However, percent coverage of cattails was less ($P = 0.050$) in the assigned treated wetlands ($\bar{x} = 70.0 \pm 4.2\%$) than in the reference wetlands ($\bar{x} = 81.5 \pm 2.1\%$). Coverage of other vegetation was greater ($P = 0.060$) in the treated wetlands ($\bar{x} = 23.9 \pm 3.4\%$) than in the reference wetlands ($\bar{x} = 14.0 \pm 2.6\%$).

Post-treatment

Percentage of open water was less (RMANOVA, $P = 0.018$) in 1993 ($\bar{x} = 21.6 \pm 4.4\%$) than in 1994 ($\bar{x} = 35.6 \pm 4.7\%$) and differed ($P = 0.036$) between treated ($\bar{x} = 36.2 \pm 3.0\%$) and reference wetlands ($\bar{x} = 21.0 \pm 5.4\%$, *Figure 1*). Percent coverage of cattails was greater ($P = 0.049$) in 1993 ($\bar{x} = 48.9 \pm 9.4\%$) than in 1994 ($\bar{x} = 33.6 \pm 7.6\%$) and varied significantly ($P = 0.020$) between treated ($\bar{x} = 25.7 \pm 3.8\%$) and reference wetlands ($\bar{x} = 56.8 \pm 8.9\%$). Percent coverage of other vegetation was similar between 1993 and 1994 ($P = 0.735$) but differed ($P = 0.052$) between treated ($\bar{x} = 38.1 \pm 3.8\%$) and reference wetlands ($\bar{x} = 22.2 \pm 4.1\%$) during those years.

Blackbirds and wetland habitat

During the pretreatment year (1992), blackbird numbers did not differ (ANOVA, $P = 0.350$) between treated and reference wetlands, averaging 13,338 ±

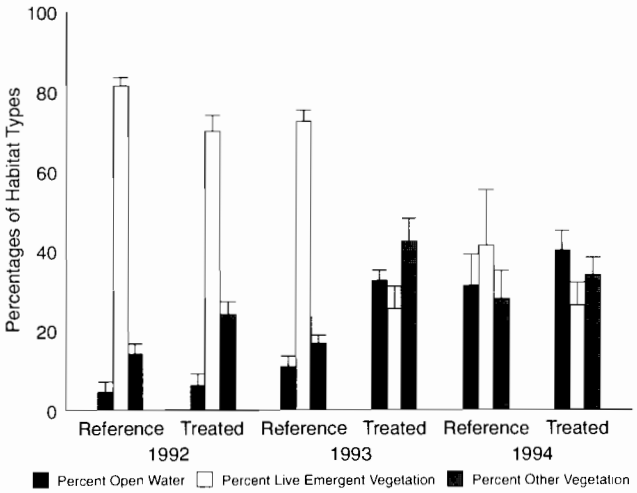

Figure 1. Habitat characteristics of eight wetlands randomly designated as either reference ($n = 4$) or treated ($n = 4$) at 70% spray coverages with glyphosate herbicide during August 1992 in southeastern North Dakota. Live emergent vegetation consists largely of live cattails and 'other' vegetation consists of live sedges, grasses, rushes and dead vegetation

Table 1. Numbers of blackbirds (Icterinae) using reference wetlands[a] and wetlands treated[a] with glyphosate herbicide in August 1992

	Number of blackbirds					
	1992[b]		1993[c]		1994[c]	
Treatment	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Treated	3577	1510	1620	1433	4183	3457
Reference	23,100	19,195	17,625	16,636	1478	545

[a] $n = 4$
[b] Pretreatment
[c] Post-treatment

9647 (*Table 1*). Moreover, blackbird numbers did not vary (RMANOVA, $P = 0.453$) between 1993 and 1994 or between treatments ($P = 0.469$), averaging 6227 ± 4185.

Linear regression analysis yielded a positive relationship ($P = 0.006$) between blackbird numbers (y) and hectares of live cattails (x). The combined years model ($n = 24$, $r^2 = 0.249$) was [($y = 442.2\,x$)]. Additionally, a positive linear relationship ($P = 0.012$) existed between blackbird numbers (y) and per cent coverage of cattails (x). The combined-years model ($n = 24$, $r^2 = 0.212$) was [($y = 184.0\,x$)].

Blackbirds and sunflower damage

In 1992 (pretreatment year), percent sunflower damage differed (ANOVA, $P = 0.030$) between treated ($\bar{x} = 1.3 \pm 0.61\%$) and reference blocks ($\bar{x} = 3.8 \pm 0.63\%$) (*Table 2*). Likewise, sunflower production loss differed significantly ($P = 0.082$) between treated ($\bar{x} = 35.1 \pm 13.0$ kg ha^{-1} year^{-1}) and reference blocks ($\bar{x} = 70.8 \pm 11.0$ kg ha^{-1} year^{-1}).

In 1993 and 1994, the percentage of sunflower damage was the same between years (RMANOVA, $P = 0.250$) and between treatments ($P = 0.460$), averaging 2.9 ± 1.2%. Sunflower loss did not differ ($P = 0.324$) between posttreatment years or between treatments ($\bar{x} = 50.8 \pm 21.4$ kg loss ha^{-1}, $P = 0.347$). However, linear regression analysis yielded a positive relationship ($n = 24$, $r^2 = 0.56$, $P = 0.0001$) between sunflower production loss ha^{-1} year^{-1} (y) and blackbird numbers (x) [($y = 0.003\,x$)] (*Figure 2*).

Discussion

Controlling cattails

Cattails begin to show signs of distress (i.e. brown leaves) consistent with glyphosate poisoning about 2 weeks after treatment. Two years post-treatment, there were fewer live cattails in treated wetlands than in reference wetlands, although new growth was evident in shallow-water and mudflat areas. Cattails reproduce rapidly through rhizomes and seeds, making it important to use a sufficient amount of herbicide to kill a high percentage of the cattails and thereby reduce their rate of regeneration in the treated areas.

Under the environmental conditions of southeastern North Dakota in August, aerially applied glyphosate at 5.3 l ha^{-1} effectively controls cattails contacted by the herbicide. Maintaining water depth >30 cm after applying the herbicide is critical for reducing the rate of cattail regeneration in treated wetlands (Weller, 1975; Merendino and Smith, 1991). Thus, it is important to maximize cost-effectiveness by treating areas of the wetland likely to maintain surface water throughout the growing season. During post-study visits, we observed that treated wetlands with water depth >30 cm remained relatively free of cattails for ≥4 years.

Blackbird response to cattail reduction

The number of blackbirds observed using the eight test wetlands decreased from an average of 13,000 birds during 1992 (pretreatment year) to 6000 birds during 1993 and 1994 (post-treatment years). We speculate the blackbirds used other wetlands outside the blocks after above-normal precipitation during 1993 and 1994 (North Dakota Agricultural Statistics, 1994) reduced the amount of available roosting substrate in both the treated and reference wetlands. Additionally, numerous formerly dry wetlands were recharged, which increased the overall availability of roosting sites in the study area. The lack of statistical differences in blackbird numbers and sunflower damage between treatments was probably due to small sample sizes, low damage levels and high variability within treatment groups.

Table 2. Percentage of sunflower damaged by blackbirds (Icterinae) in fields surrounding reference wetlands[a] and wetlands treated[a] with glyphosate herbicide in mid-August 1992

	Percentage sunflower damaged					
	1992[b]		1993		1994	
Treatment	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Treated	1.3	0.61	2.8	1.0	1.0	0.55
Reference	3.8	0.63	6.0	4.7	1.8	0.48

[a] $n = 4$
[b] Vegetation began to show signs of glyphosate poisoning about two weeks after treatment

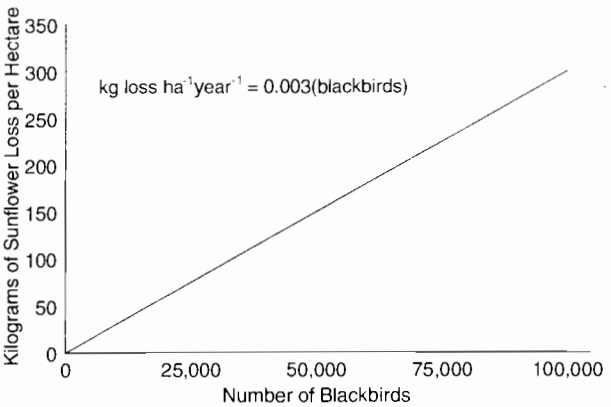

Figure 2. Linear regression analysis describing the relationship between the number of blackbirds using eight experimental wetlands in southeastern North Dakota and sunflower damage in 23.3 km^2 blocks of land surrounding these wetlands

Wetlands with dense stands of cattails located near ripening sunflower are prime locations for blackbird roosts (Otis and Kilburn, 1988; Linz *et al.*, 1992). It is logical that wetlands lacking emergent vegetation will not support roosting blackbirds. Moreover, our data suggest that large contiguous patches of cattails tend to harbor more roosting blackbirds than do narrow strips of cattails. From 1992 to 1994, treated and reference wetlands that contained ≤30% coverage of cattails, harbored <2000 blackbirds during mid-August, which coincides with the peak sunflower damage period (Cummings, Knittle and Guarino, 1989). Apparently, these wetlands provided only marginal roosting habitat for blackbirds.

Economics of cattail management

Treatment cost for this study, including glyphosate, surfactant, drift retardant and application, was about US$136 ha^{-1}. Assuming daily sunflower consumption by one blackbird is 14 g day^{-1} (Besser, 1979), each bird will damage 0.59 kg over a 42-day damage period (Cummings *et al.*, 1989). With sunflower valued at US$0.22 kg^{-1} (North Dakota Agricultural Statistics, 1994), a single bird will damage US$0.13 of sunflower $year^{-1}$. Thus, growers must anticipate an average of 1046 blackbirds (US$136.00 ha^{-1}/US$0.13 $year^{-1}$) per hectare of cattails to justify treatment costs. A treatment that is effective for at least four years requires only 262 birds day^{-1} ha^{-1} of wetland to justify costs.

Management implications

Cattail-dominated wetlands harboring >262 blackbirds ha^{-1} are relatively common in North Dakota (Linz *et al.*, 1991), and roosts containing >1000 blackbirds ha^{-1} are located each year in sunflower growing areas of the northern Great Plains (G. M. Linz, pers. obs.). The relationship between blackbird numbers and sunflower damage indicates that reducing blackbird populations by fragmenting their roosting habitat may mitigate sunflower damage. Dispersing the damage over a larger area may result in more growers receiving slightly damaged heads; however, these heads may compensate for seed loss by producing heavier seeds (Sedgwick, Oldemeyer, and Swenson, 1986). Thus, reducing the coverage of cattails in wetlands with glyphosate may be cost-effective for many sunflower growers.

The ideal ratio of open water, live cattails and other vegetation for minimizing blackbird roosting and providing habitat for other non-target wildlife is difficult to determine and is confounded by numerous other habitat factors on both local and regional scales. Presently, we are recommending that managers strive to create a 70:30 ratio of open water and cattails to minimize blackbird roosting substrate (Linz *et al.*, 1993). Creating wetlands with >70% open water may increase the efficacy and longevity of the treatment. However, this management strategy is neither advised nor supported by federal and state wildlife agencies because of concerns for non-target (non-blackbird) animal populations that require some emergent vegetation for nesting, foraging and protection (McEnroe, 1992; Stromstad, 1992). Maintaining 30% of the emergent vegetation and staggering treatments on large wetland complexes will help sustain these bird populations by providing wetlands with different stages of cattail regeneration.

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